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CIVIL SYSTEMS PROGRAM OFFICE

THE TECHNOLOGY TRANSFER PROCESS -- WHERE'S THE BRIDGE?

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THE TECHNOLOGY TRANSFER PROCESS--WHERE'S THE BRIDGE?

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Abstract

Technology developed by the space industry might help cities improve delivery system effectiveness, but diffusion of ideas between local governments and industry is not occurring naturally. The City of Fresno, under NSF and NASA sponsorship, is evaluating the nature of the bridge required to condition city decision processes to greater use of technology. It was concluded that the basic bridge required is the demonstration of the problem definition process. Promoting dialogue between active decision makers--particularly department heads--on the nature of current city problems will result in internalization and operational use of the transfer process as needs arise. The remaining tools needed for effective technology transfer projects--risk management techniques, payback analyses, project management systems, and productivity indexes--will be more easily accepted by the decision process when supported by a clear and internalized problem definition process.

I. Introduction

Local governments face a growing series of problems in providing a community with adequate service delivery systems at reasonable costs. Problems are becoming more broad and interrelated; good solutions are becoming more complex and therefore more expensive. Planning for such things as land use, transportation, and air/water quality must be done over a much longer projected time frame and for a larger land area than ever before. The community needs and attitudes, through active citizen participation processes, are imposing clear and justified demands on general purpose government administrators. Many familiar and "comfortable" service delivery techniques are fast becoming plainly inadequate.

New technologies have, in fact, started to emerge to support city administrators in their increasingly complex world. Land use planning, for example, has a wealth of computer modeling work available to draw from, as well as rapidly developing computer graphics techniques. Transportation systems are starting to draw on aerospace technology for advanced traffic control systems and new system concepts (e.g., BART).

Yet, for the excellent start that some city governments have made in relating to new technology, most cities are not new-technology oriented. Contrary to what might be expected, there appears to be little natural diffusion of already developed technology (for example, from the space program) between industry and local governments. Direct dealings between the high technology industry and city governments requires some basic adjustments to both parties involved. The industry, accustomed to dealing primarily with a highly centralized customer, must change its approach to market identification and definition within a highly decentralized group of customers, namely cities. Further, the concept of advancing the basic state of technology during product development using the customer's financial resources is not a particularly acceptable practice when a city government is the customer.

However, there are intermediate technology companies who have provided the cities with their technological progress in the past, and who understand the city marketing approach. The fact that this segment of industry has not caused a diffusion of new technology into the cities leads to the conclusion that perhaps one must examine the city's role in technology transfer to find the underlying barriers to better use of new technology. The city in fact has the problem, must decide to solve it, must fund the solution, and must be comfortable with both the process of solution and the implementable result.

The premise of this paper is that successful technology transfer must be an active process in the receiving city. Transfer of technology becomes not so much the manipulation of new technology, but rather the conditioning of the city decision process to relate to and utilize already developed technology. A bridge must be built between the technology industry and the decision process in a city which allows answers to the following, measured against its own internal set of standards: How can a city know that a new technology solution:

a) Will be beneficial?
b) Will be better than some alternative approach?
c) Is actually attacking the right problem?
d) Will produce cost-effective results?

The basic elements of such a bridge form the subject of this paper.

In the following sections a view of a city's internal process of technology transfer will be presented; the experiences of the City of Fresno with one technology transfer program will be described, and some general conclusions will be drawn.

II. City Role in Technology Transfer Process

A definition of the technology transfer process, as it is used in this paper, is necessary to form the framework for what follows. Cities now make use of technology, and in fact do increase their use of technology with time. However, the amount of technology used compared to that available, and the rate of increase of technology used compared

with the increasing need to solve city problems, are small. There is need for a process to accelerate the effective use of already-developed technology by local governments, and that becomes the basic definition--and overall goal--of a technology transfer process.

Frequent mention is made throughout this paper **of the decision** process of the city. It is often **referred** to as if it were a well-defined, tangible, **almost** organic thing. In fact, it comes closer to being organic than either well-defined or tangible. As it is used here, the decision process is that collection of points at which decisions can be made, either by action or inaction, which govern the eventual form and outcome of a technology transfer process. It may include the usual decision makers within city government, the press, the general public, etc.

Let us now examine the nature of the internal process a city must go through to accelerate the use of technology. The steps in the process might look like this:

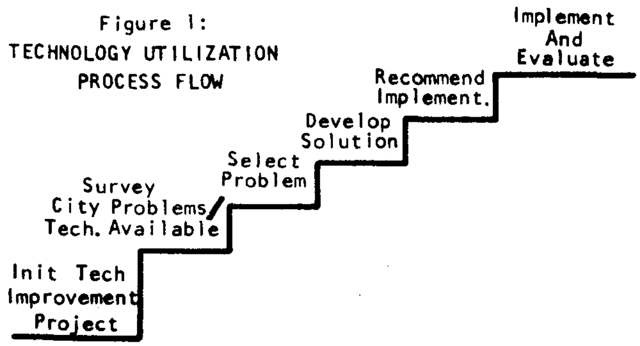


Figure 1:
TECHNOLOGY UTILIZATION
PROCESS FLOW

Within this general process flow for promoting the utilization of technology, there are four key points where the city decision process must act in a positive and overt way. Each of these decision points requires action by different parts of the decision process. These factors are shown on the process flow as follows:

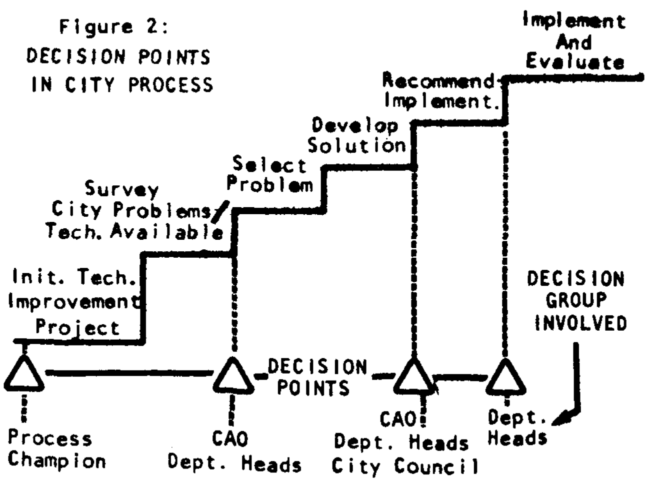


Figure 2:
DECISION POINTS
IN CITY PROCESS

It is important to start the process in a purposeful way. In the absence of a formal commitment to utilize technology more effectively, problem solution will tend to start with the "select problem" step--most often an imposed problem or crisis--and the group responsible for solution will often have neither the time nor the approval of the decision makers to look at the use of new technologies.

The key decision maker who iniates the technology utilization program can be anyone within the ranks of the reasonably influential in the city--an individual councilman, the CAO or one of his key staff, a department head or even a technical specialist within the operating departments. The entire process could be started primarily on the urging and commitment of that one process champion. The problem selection decision falls to the operating groups, represented by the department heads and the CAO. The next decision, that of actually implementing a solution, involves the broadest commitment of the decision group. It may represent the first time the council is involved in a real way in the technology utilization project. Though in some cases the council could have been involved in the initial decision that starts the entire process, agreeing to commit minor resources to study technology utilization is easy (and politically wholesome) compared with agreeing to commit larger amounts of financial and manpower resources to implementation. Finally, once implementation is agreed to, the operating departments actually run the project to completion through a series of operation decisions.

A successful technology utilization process requires that these four key decision points be properly understood and managed. The quality of each decision affects directly the quality of each succeeding decision in the chain. Let us now examine the nature of the decision at each point in the process by looking at three main questions:

1) What are the factors bearing on the decision?

2) What are the barriers to an "effective" decision being made?

3) How can those barriers be overcome?

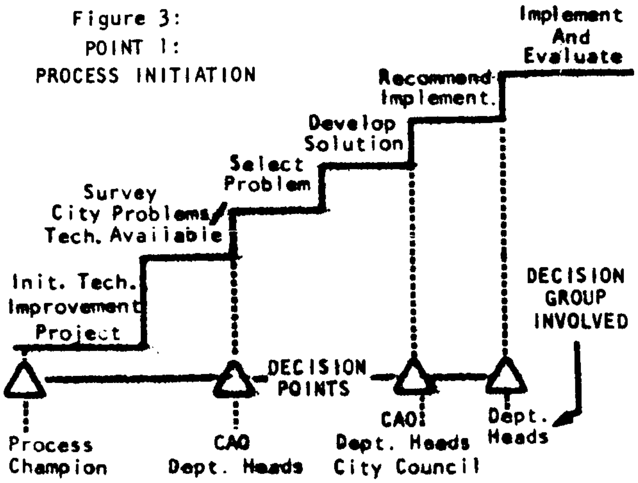
<u>Decision Point 1: Starting a Technology Improvement Project</u>

The decision to start a purposeful technology utilization project can be described as shown in Figure 3.

The influence of possible grant funding in this decision is strong. The federal government is providing significant incentives through a number of programs to promote use of technology in local governments. The RANN program (Research Applied to National Needs), the Technology Incentives program and the Technology Assessment program, funded through the National Science Foundation, are a few examples of sources of financial support for innovations in technology utilization.

Given the existence of an individual commitment to initiating a project, the barriers can be overcome by showing technology utilization successes in other local governments. Cooperative projects between local governments might prove effective,

Figure 3:
POINT 1:
PROCESS INITIATION



Decision factors:
- o Obvious need exists
- o Attraction of possible grant funds
- o Understanding of technical disciplines
- o Personal "charisma" of initiator

Barriers to effective decisions:
- o Difficult to show eventual economic payback
- o Natural resistance to change

Barriers overcome by:
- o Successful experience of other cities
- o Specific problems pre-selected
- o External incentives (e.g., grant funds)
- o Cooperative projects (city/city, city/county, etc.)

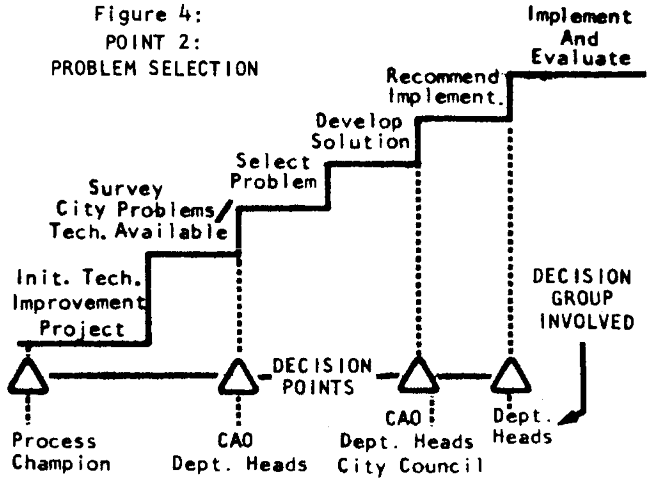
particularly if a high level of cooperation already exists between them through existing delivery systems.

Commitment at this step is relatively easy to obtain because the resources required to complete this step are generally small, and the results of the city problem survey would be useful even if the program were carried no further. However, commitment to start a technology utilization project on that basis is not solid enough to carry a project through final implementation, and it would be unreasonable to expect any more solid support from the decision process at this stage than tolerance and an open mind.

<u>Decision Point 2: Selecting Specific Problems for Solution</u>

Staff work following program initiation involves selecting those city problems which appear to be both important and technology-related. A candidate problem list so developed must now be acted on by the decision process and specific problems selected. This decision point is characterized in Figure 4.

Figure 4:
POINT 2:
PROBLEM SELECTION



Decision factors:
- o Perceived need for solution
- o Clear payback necessary
- o Mandated projects selected
- o Visibility/citizen input
- o Personal/pet projects favored
- o No threat/harmless projects

Barriers to effective decisions:
- o Defensiveness-individual/organization
- o No willingness to take risks
- o No problem definition process
- o No R & D process

Barriers overcome by:
- o Select problems with developed/demonstrated hardware and technology
- o Department heads involved in problem definition/selection
- o Citizen groups endorse project/approach
- o CAO/Council endorsement on problem selection and payoff validity

The strong influences on this particular decision point appear to be of three basic types. First, the problem selected should be a "legitimate" one--that is, one for which the selection rationale is clear and supportable by groups outside of the selecting body. This might include mandated projects (e.g., air quality improvement), or those with an economic payback justifiable to such groups as the council, citizens' groups, and the like.

Second, the personal and organizational characteristics of the decision maker and his group steer the selection process. Local governments are classically risk-adverse. The penalties for failure imposed by "the system"--primarily the council, the press and the community--are great, while the accolades for success are largely taken in stride by that same system. The strong tendency is to again select problems that are either mandated for study, are of real interest to "the system," or are harmless. Failure is then either insignificant or understood, and risk is minimized. The natural tendency to resist change and maintain a stable "comfortable" approach to service delivery systems enters the decision process here, and can influence the department head's actions.

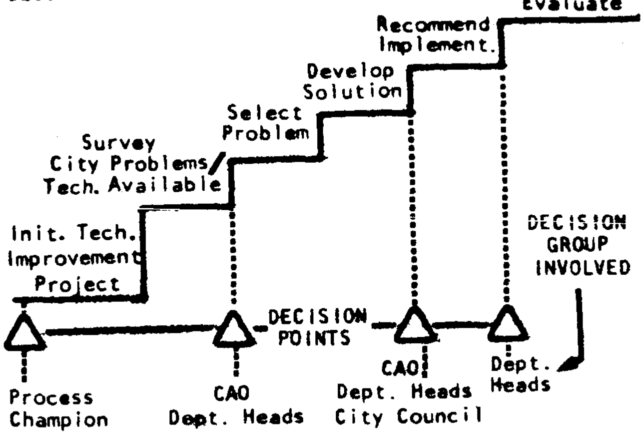
Third, two very basic processes needed to reach the proper decision at this point are characteristically missing in most local government decision processes: (1) the concept of clear problem definition, and (2) the existence of a research and development (R & D) activity. Problem definition is difficult because the organization is decentralized, with authority resting with heads of functional departments. Coordination of problem definition across those functional lines is random at best in the strongly political environment that usually exists. The result is that problems are either incompletely described or are attacked from an artificially narrow point of view. Good problem definition--the equivalent of the "phase zero" technique of the space program--requires the functional departments to modify their thinking and in fact to submerge their own internal objectives in favor of promoting the objectives of a group of departments. This comes with great difficulty to a system which not long ago granted almost complete autonomy to functional managers in the commissioner form of government. A second process, also largely foreign to local governments, is the R & D process. A continuing development and prototype evaluation process conducted by a city would provide for orderly evaluation of new ideas and new hardware systems. Experience and confidence developed with practice on prototypes will help support proper and timely use of new systems on future problems will help overcome the reluctance to use new hardware to solve crisis-type problems and will strain out unworkable ideas before large dollar investments are considered.

Decision Point 3: Recommending Project Implementation

The implementation decision involves the allocation of major resources to the solution of a specific problem. It also most likely marks the only formal action required of the council. This decision point is diagrammed in Figure 5.

This decision point requires the balancing of resources required, risk involved, and payoff expected. Incomplete analysis performed in the previous steps of the process take their toll here, and worthwhile projects can lose their support for lack of careful planning and analysis. There is no substitute for a strong analytical base to problem solution except faith in the ability of the staff to produce under any circumstance--a tenuous and uncomfortable premise for both the staff and the council. A new factor enters the decision process as well at this point--an evaluation mechanism to measure the results of a proposed project. The existence of productivity indexes can form the unbiased basis for assessing payback so essential to making good project implementation decisions. Productivity indexes attempt to define a basis for measuring the effectiveness of a delivery system--for example, the solid waste collection system of a city. The objective of the delivery system is established and a series of measurable factors bearing on the delivery process are identified and

Figure 5:
POINT 3:
DECISION TO IMPLEMENT SOLUTION



Decision factors:
- o Payback definition
- o Availability of staff time
- o Competing needs for scarce resources
- o Citizen pressures
- o City staff versus consultant services

Barriers to effective decision:
- o Incomplete problem analysis
- o R & D process missing
- o Ineffective citizen group coordination mechanism
- o Unbalanced risk/payoff
- o Incomplete payback/analysis
- o No productivity measures

Barriers overcome by:
- o Phased implementation for risk minimization
- o Clear payback analysis
- o Involvement of full decision process in problem definition and selection

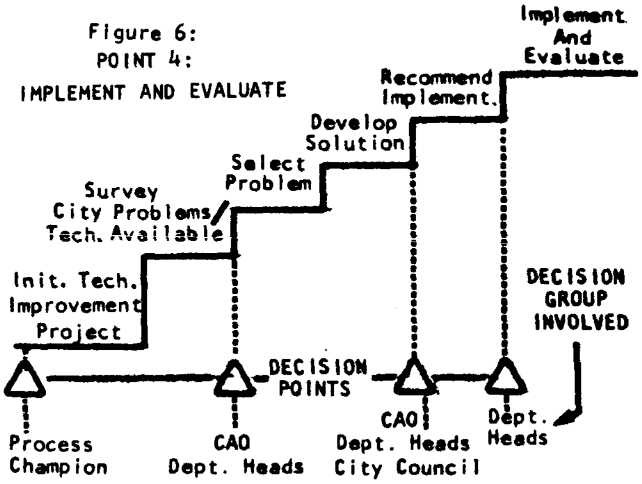
related mathematically in a measure or index. Changes in the quality of a delivery system resulting from new approaches (using new technology, for example) can be measured by noting any changes in the index.

Decision Point 4: Project Implementation

This decision point is in fact a series of decisions required to run, complete, and evaluate a project, and is diagrammed in Figure 6.

Productivity indexes support the project implementation decisions in a number of ways and become most valuable tools both for making decisions and for showing progress. The new factor entering the decision process at this point is the need for a functioning program management system for project crossing functional lines. A strong pre-disposition against an internal program manager may result from the decentralized decision process so basic to many

Figure 6:
POINT 4:
IMPLEMENT AND EVALUATE



Decision factors:
- o Risk minimization
- o Personal objectives/biases
- o Public approval

Barriers to effective decision:
- o Decentralized decision making
- o Staff time limited
- o Program management system not familiar/ available
- o Productivity indexes lacking

Barriers overcome by:
- o Development of productivity indexes
- o Staff training in program management
- o Use of outside program management service
- o Community/press involvement

city functions. In some cases, the use of an outside company as an independent program manager may provide a reasonable and effective approach--particularly if outside technical work will be required as well.

The barriers to city commitment to use new technology can be summarized as:

1) No R & D process,
2) Difficulty at clear problem definitions,
3) Oversensitivity to risk taking,
4) No clear measures of productivity, and
5) Minimal program management experience.

The combination of these factors suggests that any process of technology transfer will only be successful if it actively involves department heads in every step of the process. They are necessary either to the development, use, or acceptance of the processes to resolve each barrier listed above. The decision process is not one that will allow heavy external involvement without equivalent involvement of city staff. It is largely the involvement of that staff which causes decisions to be made and progress to occur. Lack of involvement will result in little action and only token increases in technology utilization. The role of the outside agent becomes one of catalyzing the decision process where it needs it, and causing the city involvement so essential to successful technology transfer. The technology utilization process then becomes internalized in the city operations and is available to support problem solution as required. This, then, should be the objective of any formalized program of technology utilization process development--to cause city involvement in a demonstration of technology utilization and to internalize those processes within city operations.

A brief description of such an approach in use in Fresno, California, is presented in the next section.

III. Fresno Technology Transfer Project

Since mid 1971 Fresno has been one of four California cities involved in "A Pilot Demonstration Project of Technology Application from the Aerospace Industry to City Management," hereinafter referred to as the Four-Cities Program. Specific objectives as originally stated were to:

1) Determine the ability of industrial aerospace professionals to contribute directly in the environment of the cities at this level.
2) Determine the nature and amount of technical support required to implement a program to bring aerospace technology to local governments.
3) Expose city personnel to the "systems approach" and thereby enhance their performance through this educational process.
4) Expose aerospace personnel to the sociopolitical process in the cities to enhance their understanding of the cities' problems.
5) Assess the applicability of aerospace technology and expertise to problems of the cities.
6) Evaluate whether or not this type of arrangement is beneficial to the cities and to the aerospace industrial community.

Each of four California "high technology" corporations has provided a professional to one of the four participating cities. The current pairings are:

Fresno: JRB Associates, subsidiary of Science Applications, Inc. (SAI)
Anaheim: Northrop Corporation
Pasadena: Space General
San Jose: Lockheed Missiles and Space Company

The program is sponsored jointly by the National Science Foundation (Office of Intergovernmental Science and Research Utilization) and NASA (Technology Applications Office). The Jet Propulsion Laboratory, California Institute of Technology, is Program Manager.

The program is unique in that it addresses all the major elements of the technology transfer process. It allows study of the role of the recipient, the donor, and the transfer mechanism within a single program structure. The program provided the flexibility for each city to develop the type of projects and relationships most responsive to its needs. One of the most interesting results of the program has been the contrast in approaches in each city, reinforcing the premise that the right transfer process for a city must be tailored to that city based on the specific needs and active involvement by the city itself.

The Fresno activity was started and promoted by the Chief Administrative Officer (CAO). He was an excellent example of the "process champion" described in the previous section as essential to starting a technology transfer process. The Science and Technology Advisor reports directly to him, attends all CAO staff meetings and all department head meetings, and operates as a member of the CAO staff.

Project selection for initial work was done jointly by the Advisor and the CAO. A series of meetings was held between the Advisor and each department head. The program objectives were described, and the department head was asked to recommend candidate problems to be addressed. Selection was made from the list with the concurrence of the CAO. Work approaches were then developed by the Advisor and the department head or his staff. This process lead to the selection of four main projects which would form the basis for the study and development of a technology transfer approach for Fresno. The four projects are:

Project No. 1: Solid Waste Management. The objective is to identify, analyze, and rank various resource recovery processes for the Fresno region. A computer model developed by SAI will be used to analyze local data on the volume and composition of solid waste and likely markets for recovered resources.

Project No. 2: CATV. The objective of this project is to start development of a community use plan for CATV and to set up a process for continued liaison with all organizations involved during construction of the system. Status of FCC investigations, project schedules, and system details are being reported by the Advisor. A significant citizen contact program is planned to initiate development of a use plan for the access channels.

Project No. 3: Internal Reporting System. The objective is to design and implement a simple project status reporting system for information flow from department heads to CAO to city council. After many discussions with key operating and administrative managers, a compatible set of forms was developed and reporting topics outlined. The fact that the Advisor could maintain an objective status during report system design was a strong factor in the successful development of report content and format. The system is now in its first trial run. As an extension of this task a survey on application of new microfilming techniques is being made for possible city use.

Project No. 4: Regional Planning Policy. The purpose of this project is to define a city policy and position relative to the regional planning process. As the chairman of a task force, the Advisor has published documents outlining an overall position, and is now involved in developing specific action proposals relative to COG participation. Briefings have been given to the mayor and several council members on trends in regional planning activities at state levels.

The projects which have been selected in Fresno were chosen with an overall objective in mind. The underlying philosophy of desirable transfer of technology in this city is process demonstration and internalization--most importantly, the processes of data acquisition, planning, decision making, and project management. A number of programs of varied process content were therefore desirable, as opposed to a single large project. Further, those projects which could and should be continued as internalized processes would be most beneficial. The selections follow that general pattern:

1) A hardware planning project (solid waste management)--only one element of an overall plan is attacked; the rest will be done by the City as part of a state-mandated regional solid waste management plan.
2) A policy plan (regional governments)--initial proposals for restructuring City relationships to COG and APO's will only be a start towards full policy implementation.
3) An administrative plan (internal reporting process)--the system being developed is modular, and only the first elements are treated. The extension to microfilming systems is also a future consideration.
4) A program management project (CATV)--demonstrating the approach to project schedules and coordination of multiple tasks, to be continued by the City as cable is installed.

So much for plan and approach. The following represents a summary of results to date, and relates them to the discussion of the previous section. The experiment was started successfully, largely on the basis of the personal commitment of the CAO. Nearly everyone in the City accepted that increased technology utilization was good as an objective. Although no specific, direct intended payback was clarified, there was no direct cost to the City, since the Advisor's salary was subsidized by the National Science Foundation. The concept of four cities cooperating in this venture further minimized the risk of innovation, and the program became reality.

Problem selection required the support and overt action of the department heads. The list of candidate projects generated by department head contact was disappointing, but in retrospect was understandable. There was not real communication and understanding by either the Advisor or the department heads on the nature of the transfer process. The projects were largely software projects, and mostly oriented towards processes outside of department control (e.g., CAO reporting requirements). The typical reaction was protection of department internal operation. Though the Advisor was being accepted personally, the department heads had not accepted the viability of improved operation through technology utilization. They saw, in effect, an undertaking of some risk with no identifiable payback, and resisted opening up their own departmental problems to that situation. There had been no council endorsement, no citizen group endorsement, only the personal urging of the CAO. Hardware projects would eventually involve capital outlay, and would probably be high visibility projects, both considerations increasing the perceived risk significantly. As in most cities, there was no continuing R & D activity to spawn new hardware ideas within the City. The development of new hardware is left to suppliers who approach cities with fully developed and proven systems with the cities taking little risk of non-performance of the hardware. Suggestions that perhaps problems spanning several departments should be evaluated produced no reaction at all.

In view of that result, the Advisor selected the projects described earlier in the hope that they would lead to broadened City involvement and enhanced understanding of the basic processes required for technology transfer. In fact, that does appear to be happening, but at a rate much slower than originally expected. The basis for expansion of the process has become the growing interpersonal relationships between advisor and department heads. That feeling of trust can offset the lack of defined paybacks and the real aversion to risk-taking. As a demonstration of the progress that has been made, the Advisor recently asked department heads to once again look within their activities to suggest delivery system problems which they would like to have addressed. Where initially there were none, some 15 hardware-related projects have now been identified.

The Fresno experience has confirmed clearly the advantage of having an independent science advisor. The alternative of having a city employee perform this role is destined for difficulties, for he cannot play the role of unbiased catalyst convincingly. Once a technology awareness program is functioning, this role can be internalized as well, but it is more effective initially when performed by an outside agent.

There are still difficulties, however. Because there have been no projects developed to date which produce quantifiable results (economic paybacks), the support of the council and the community is spotty. Capital-intensive projects would be difficult to implement unless the need was urgent or the risk was low. Neither suits well the concept of extension of technology utilization--the first because of time constraints, the second because of the inherent risk of such technology transfers. Only minor advances have been made towards developing a problem definition process, though an understanding of the need for such a process is developing. The concept of program management is in a similar position and will likely parallel the development of problem definition, since both are interdepartmental in nature.

IV. Overall Conclusions

The Fresno experience of the last two years has led to some general conclusions on the technology transfer process:

1) Active projects for technology utilization will be considered when the decision process in the city is convinced that a need exists. An actual need will not be operational until that need becomes a perceived need to the decision process.

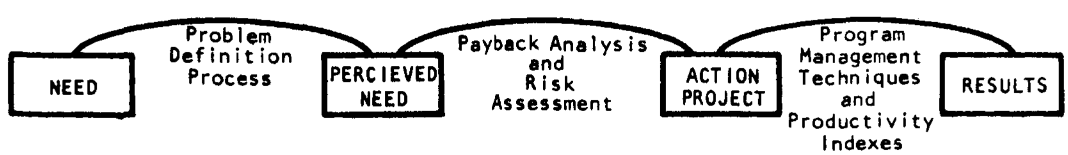
2) The bridge required to catalyze the perception of needs is a clear, active, internalized problem definition process. Without such a process linking the decision makers, technology utilization will not be used with either effectiveness or continuity by a city. This process is not a natural or comfortable one to the typical city decision process because of the extensive decentralization of decisions, and is the most significant tool to be provided by an external technology transfer agent.

3) The remaining tools needed for internalized technology utilization--payback analyses, risk management, program management systems, and productivity indexes--will follow from the pressures already existing on the decision process to satisfy perceived needs. The techniques must be developed, but will be accepted without major difficulty if relevance to the perceived need is maintained. The progression of actions and the linking bridges are diagrammed in Figure 7.

4) A technology transfer agent must stress the human relations side of the task, and he must be carefully chosen for his capabilities in sensing and managing the reactions of the people making up the decision process.

Figure 7:

BRIDGES IN THE TECHNOLOGY UTILIZATION PROCESS



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